The impact of observational nudging and nesting on the simulated meteorology and ozone concentrations from WRF-CMAQ during the DISCOVER-AQ 2013 Texas Campaign

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07/21/2014

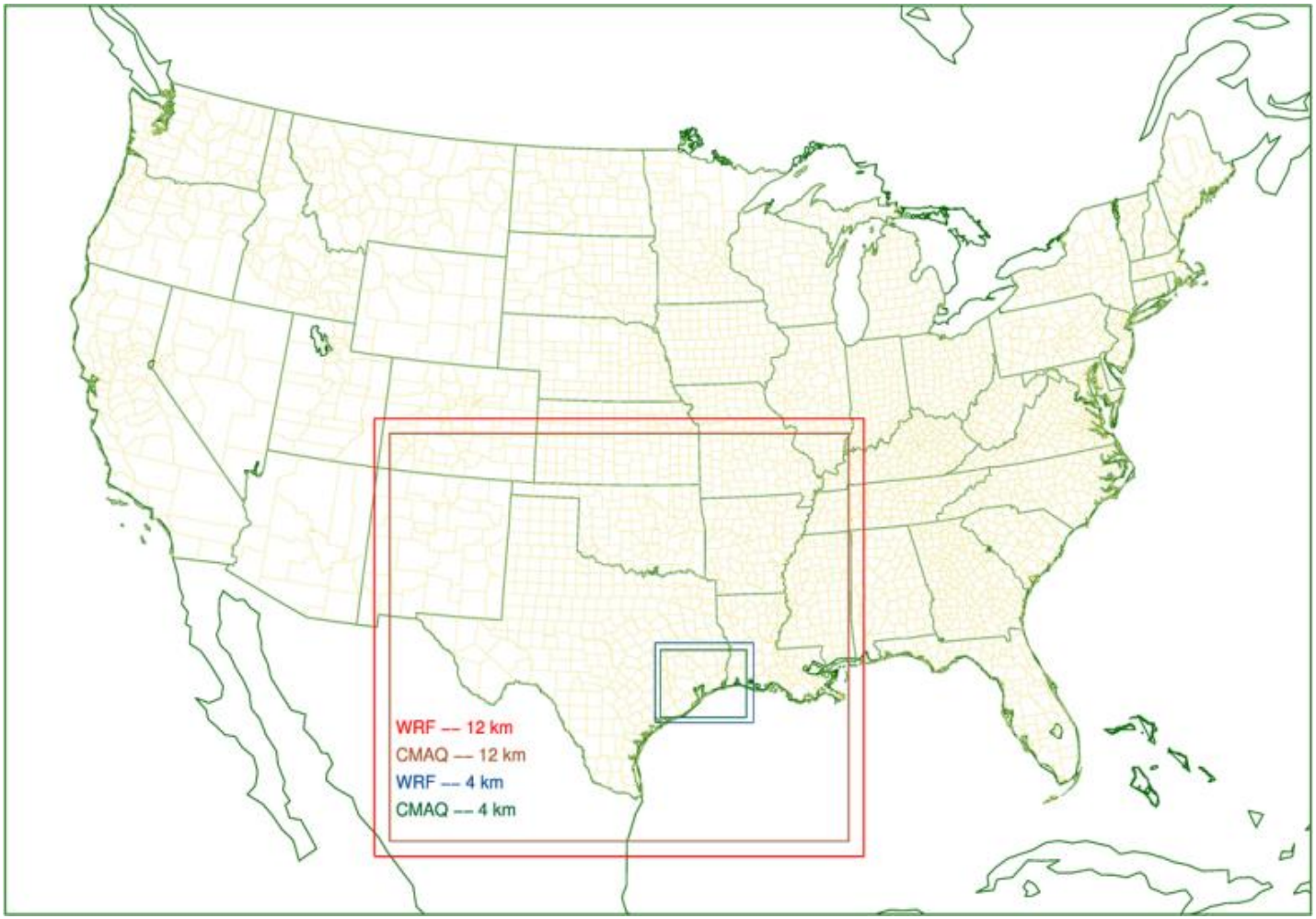
DISCOVER-AQ Simulation

- September 2013
- Four complete set of WRF-SMOKE-CMAQ simulations; new model version and 2008 inventory

WRF Cases	Type	# of Domains	Input Analysis Data	FDDA Obs-Nudging
AQF	Forecast	1	NAM forecast	N/A
NARR	Analysis	1	NARR analysis	Off
NARR-OA	Analysis	1	NARR analysis	On
NARR-Y2D	Analysis	2	NARR analysis	On

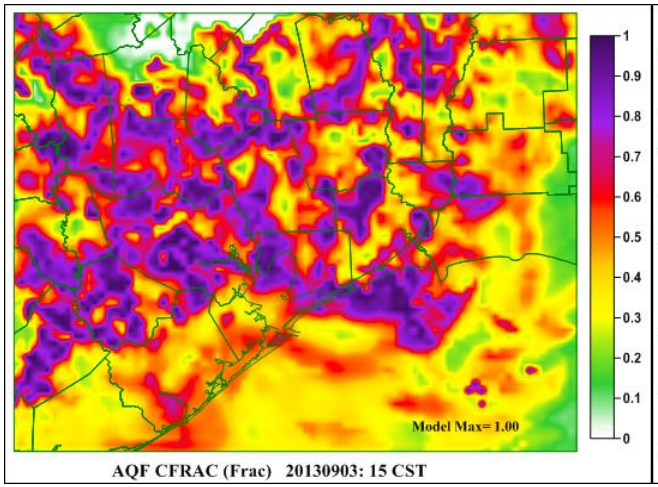
- Detailed analyses
  - By Period (three 10-day period)
  - Variables
    - Meteorology: T/U/V/CFRAC/CLDT/TEMP2/PBL
    - Chemistry: Ozone/NO/NO_2/NOx/Isoprene etc

DISCOVER-AQ Simulation

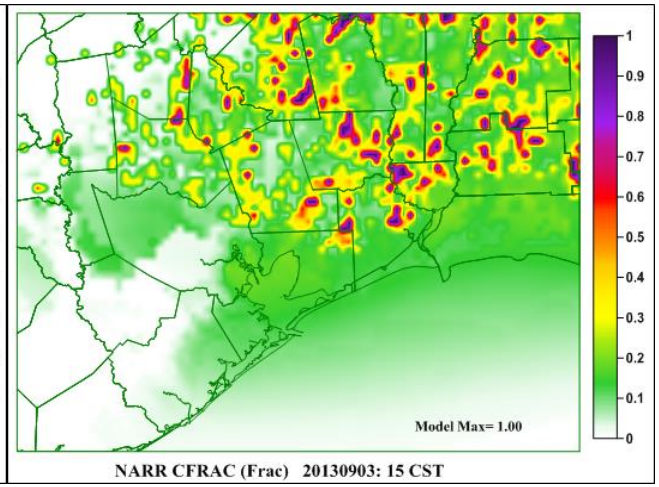


DISCOVER-AQ Simulation

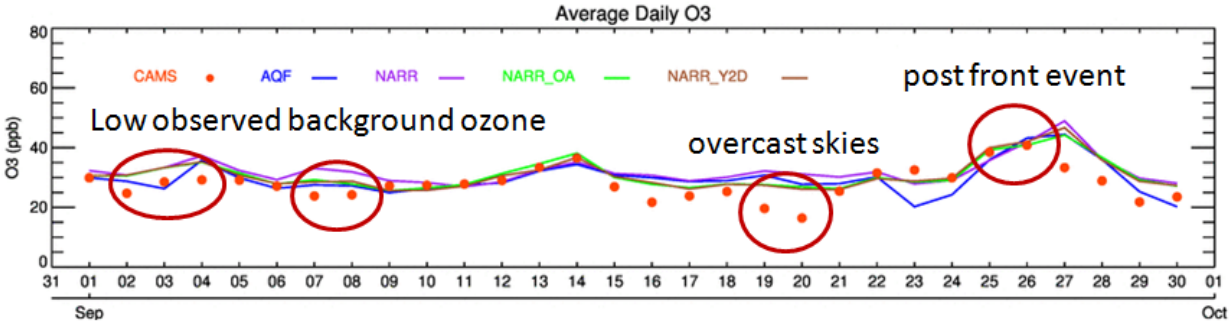
- Analyses
  - Various satellite cloud, radar images and weather charts
  - Hourly precipitation data
  - Full statistics (CORR, IOA, MB, MAE etc) for major variables ($T/U/V/O_3/NO/NO_2/NOx$)
    - Daily
    - By site
    - Day-time
    - Night-time
  - Spatial and time-series plots
  - High ozone episode due to front passage (09/25-09/26)
  - Inland and coastal sites
  - Background ozone
  - Bogus thunderstorms

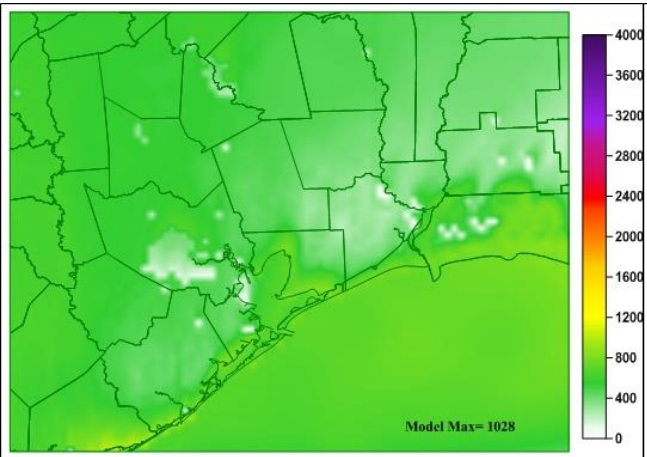


AQF CFRAC (Frac) 20130903: 15 CST

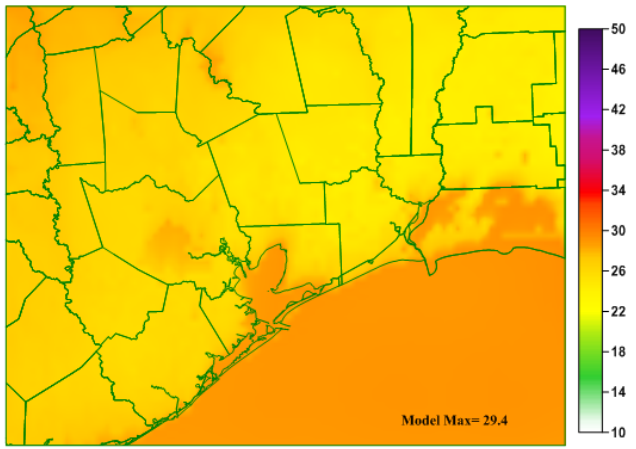


NARR CFRAC (Frac) 20130903: 15 CST

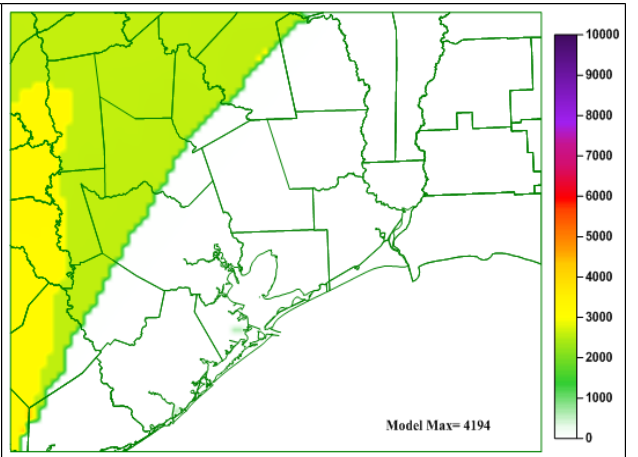




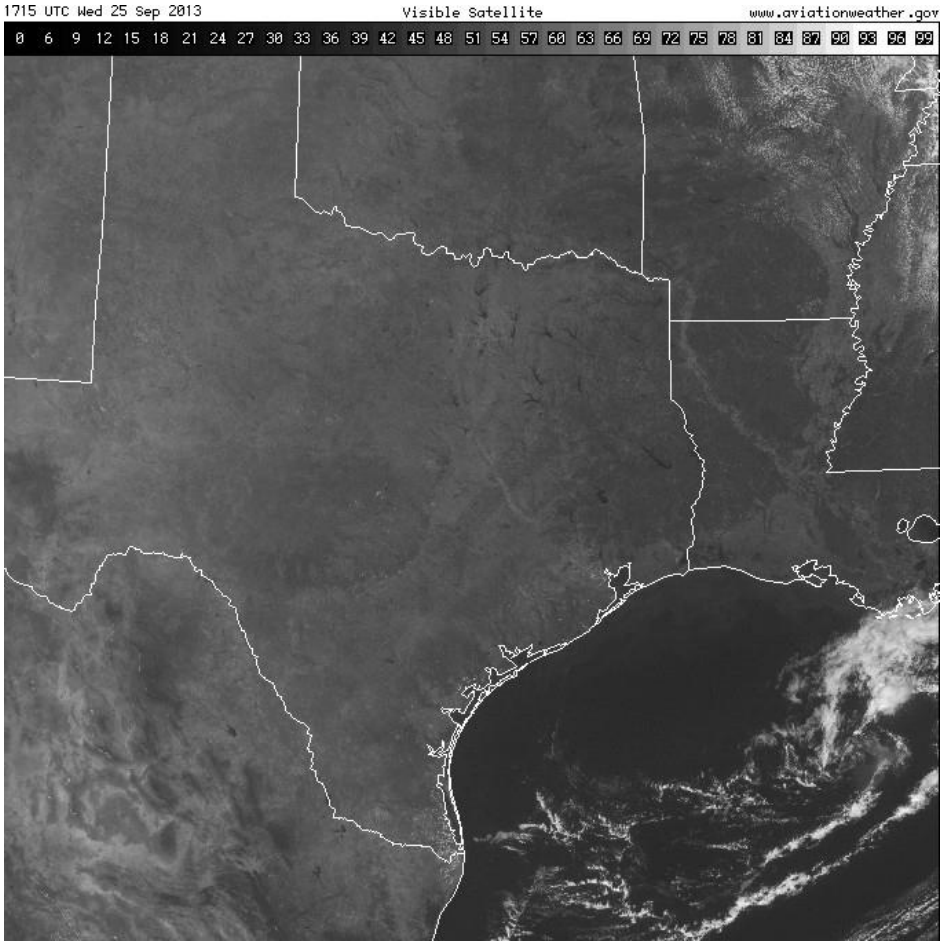
NARR PBL (m) 20130902: 00 CST



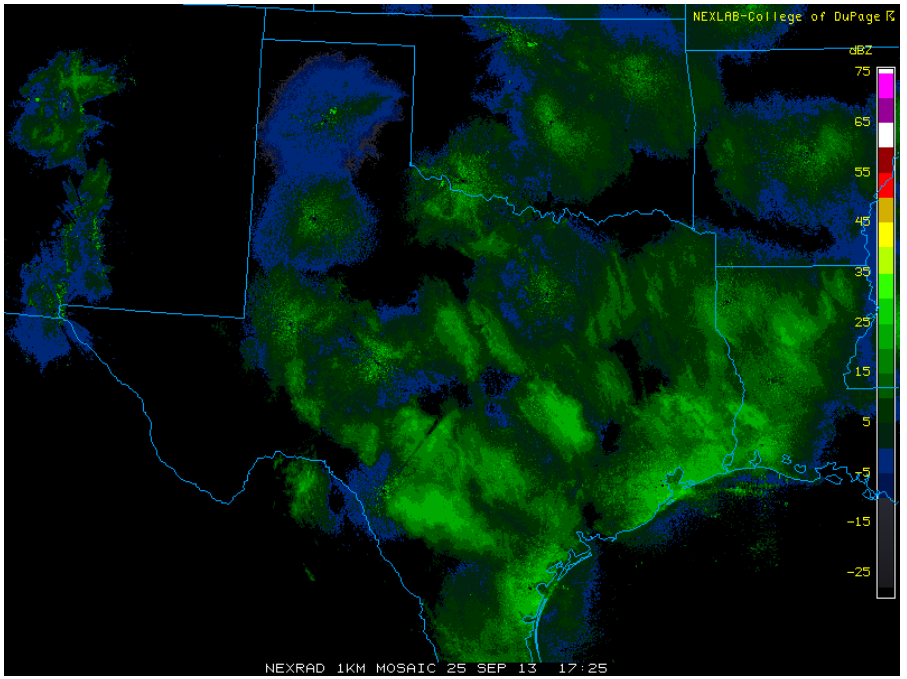
NARR TEMP2 (C) 20130902: 00 CST



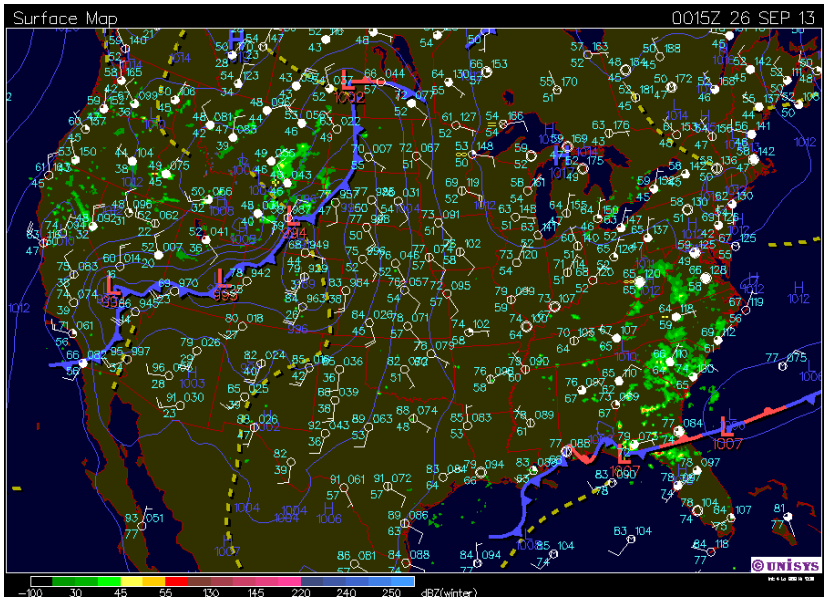
NARR CLDT (m) 20130902: 00 CST

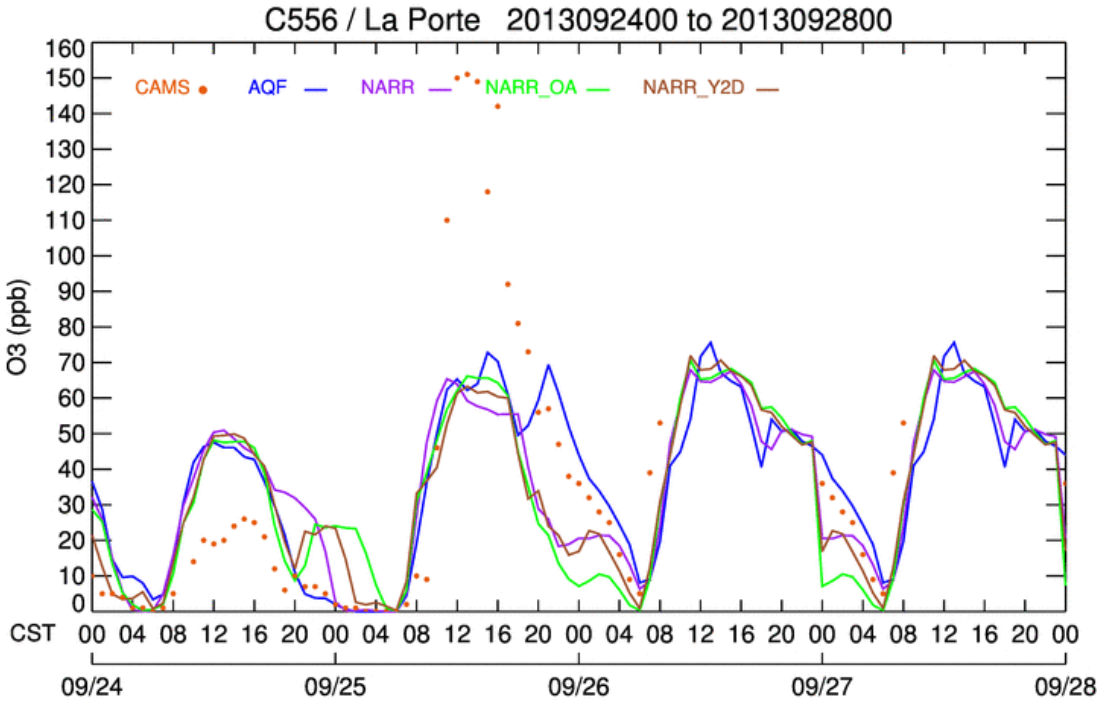


Satellite Visible – 20130925_11 CST

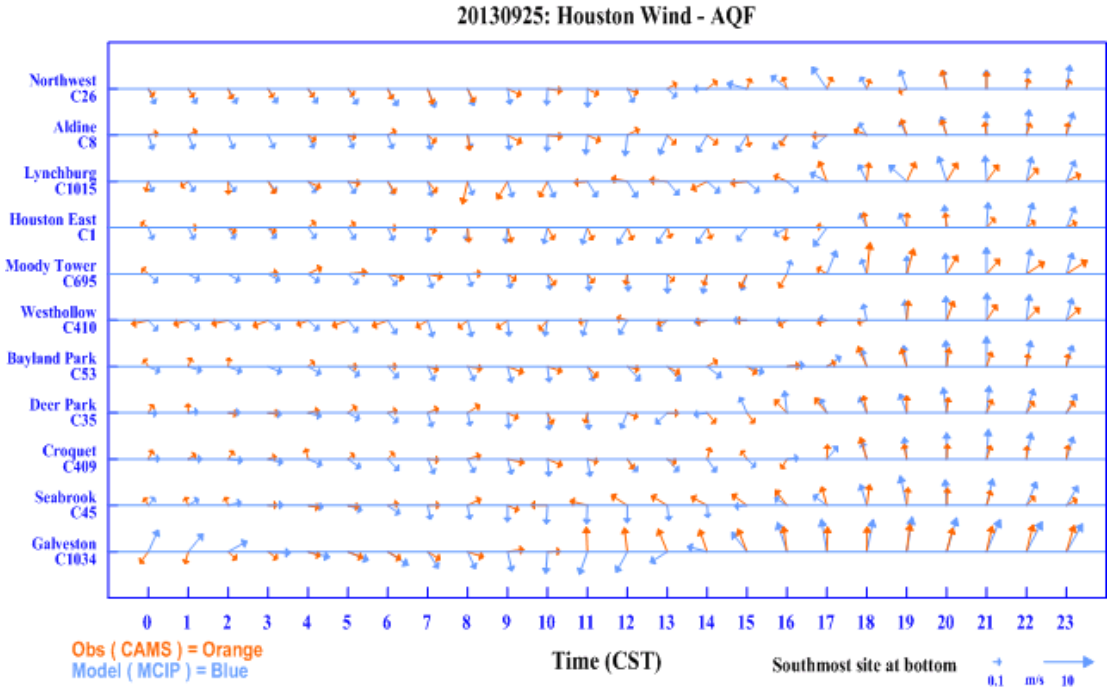


Radar – 20130925_11 CST



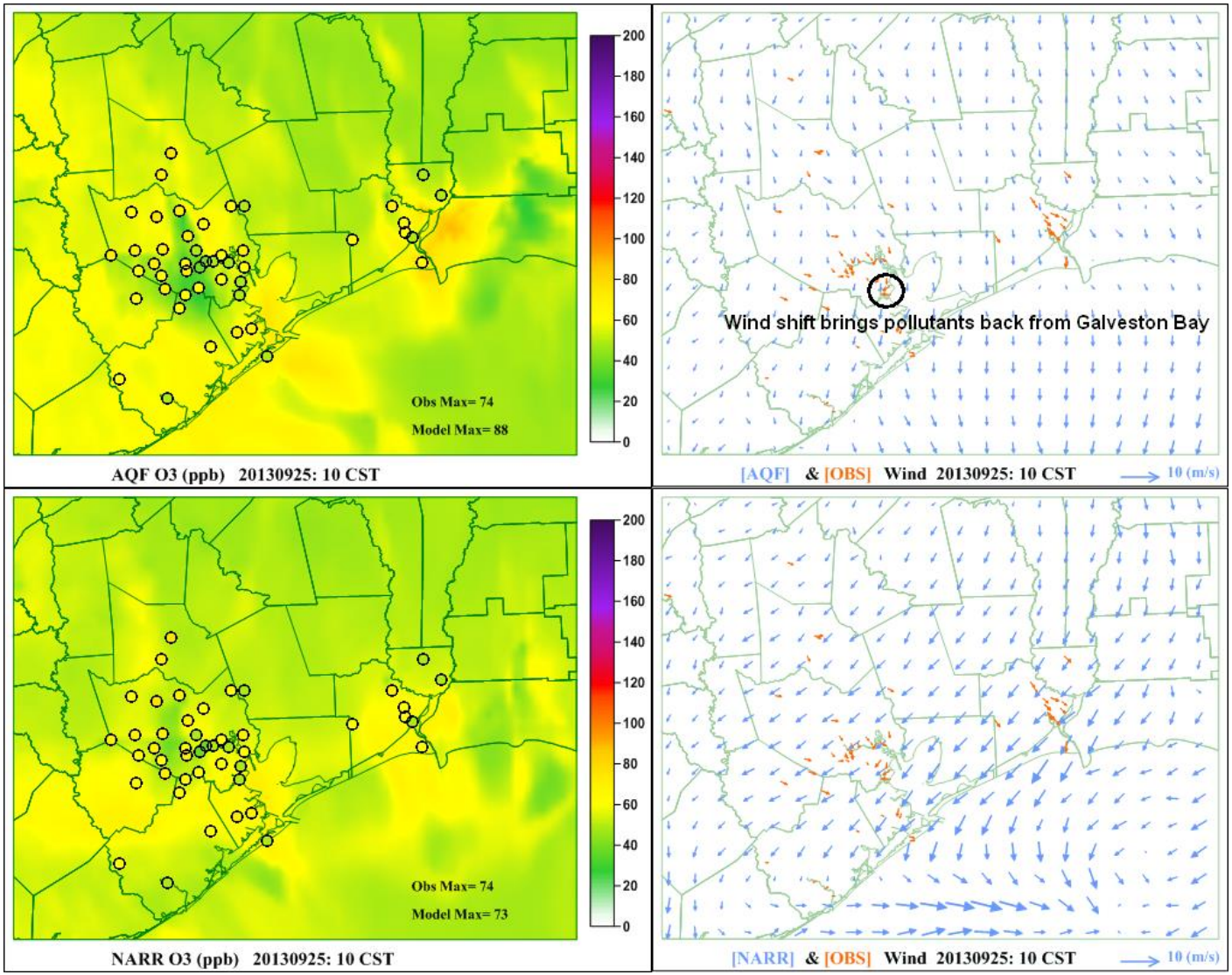


Ozone at La Porte

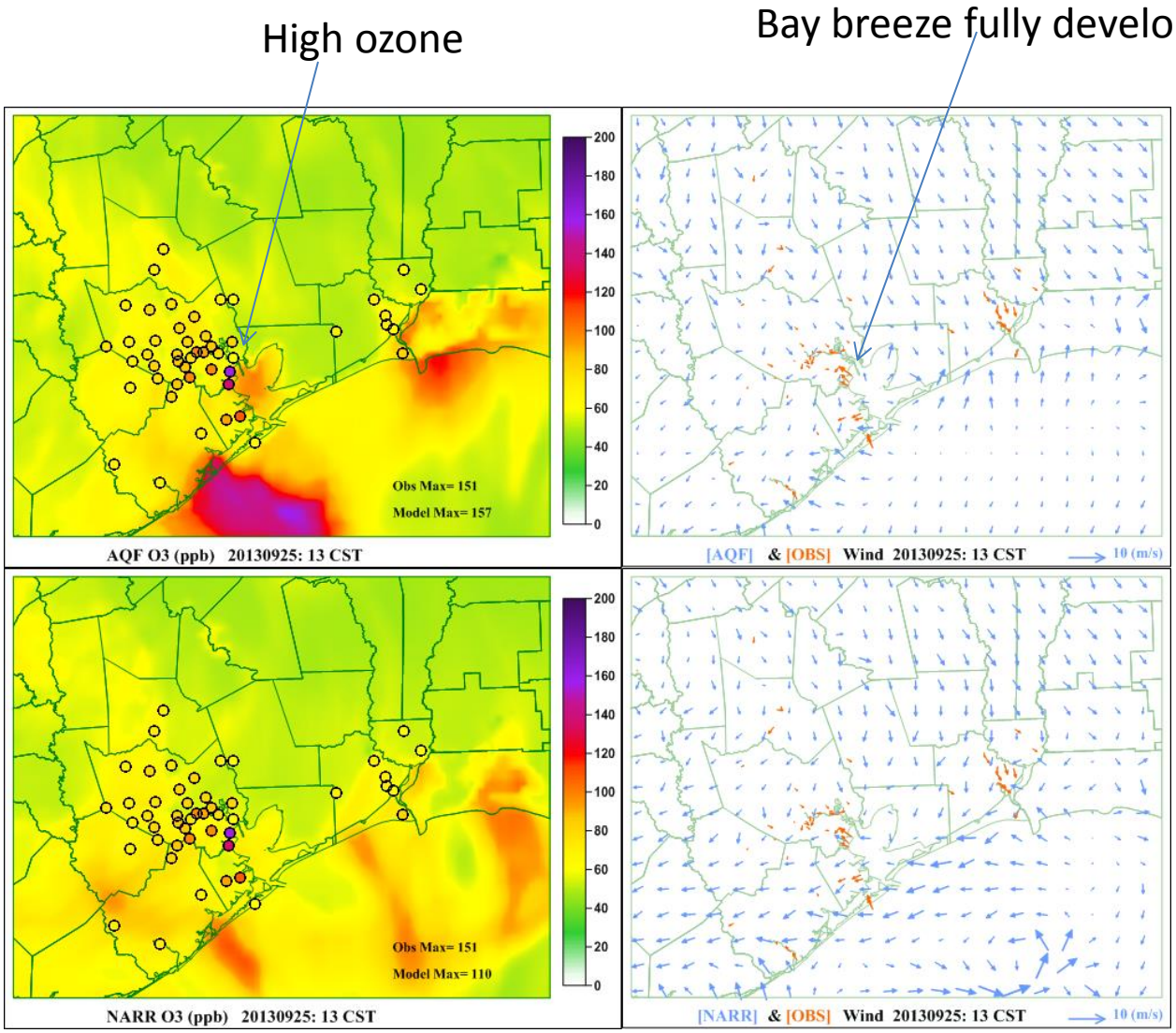


Wind shift on 20130925
11 sites at Houston

09/25 high ozone

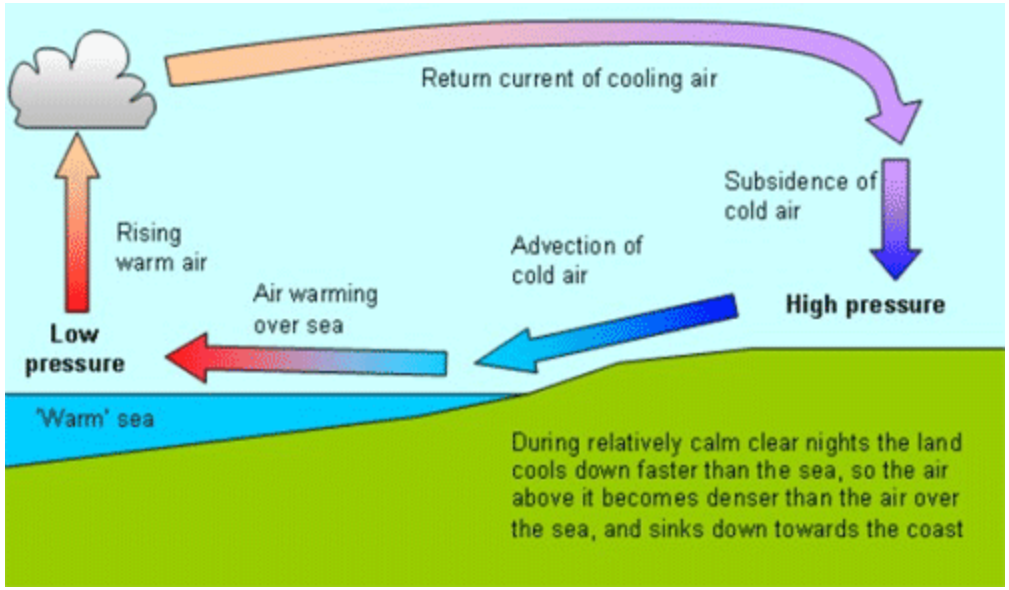


Model missed the high ozone around La Porte



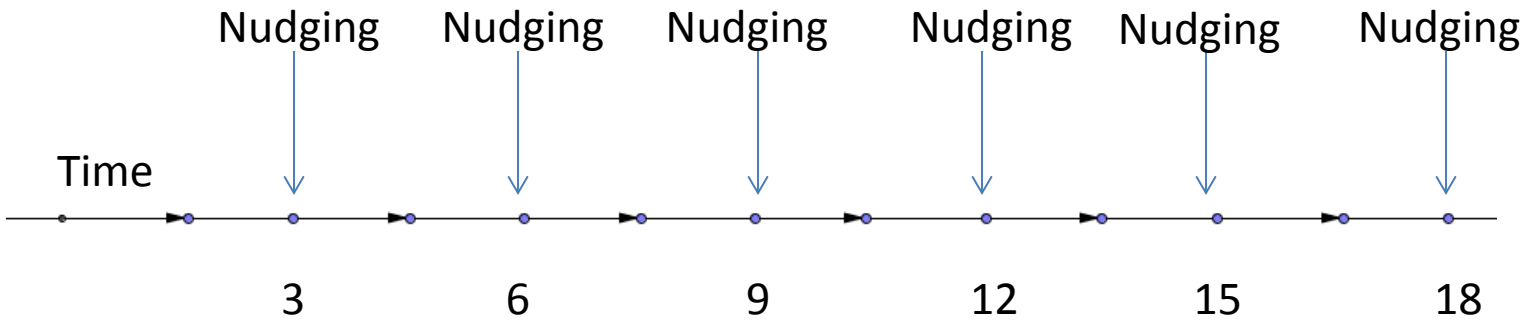
Land/Sea/Bay breeze etc

- Land breeze and sea/bay breeze
- Local wind reversal, convergence
- Small-scale phenomenon, short life time, a few hours
- Occurs when large scale forcing is absent -> prone to high ozone
- Extremely important for simulating high ozone episode
- Hard for WRF to replicate

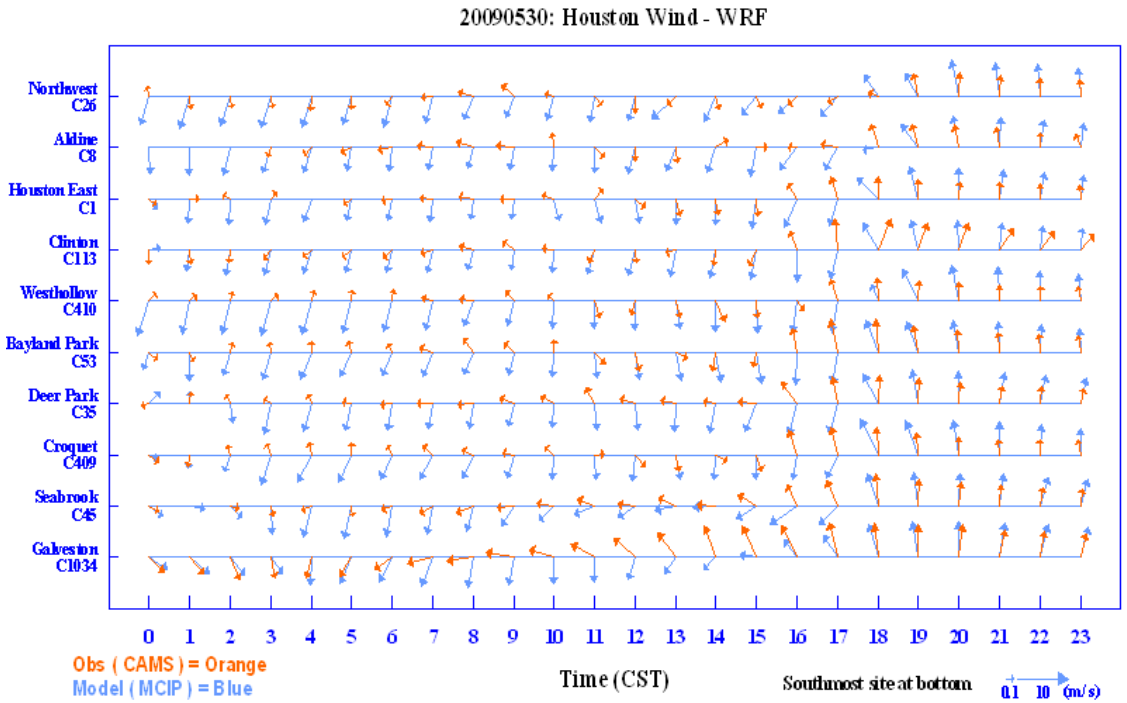


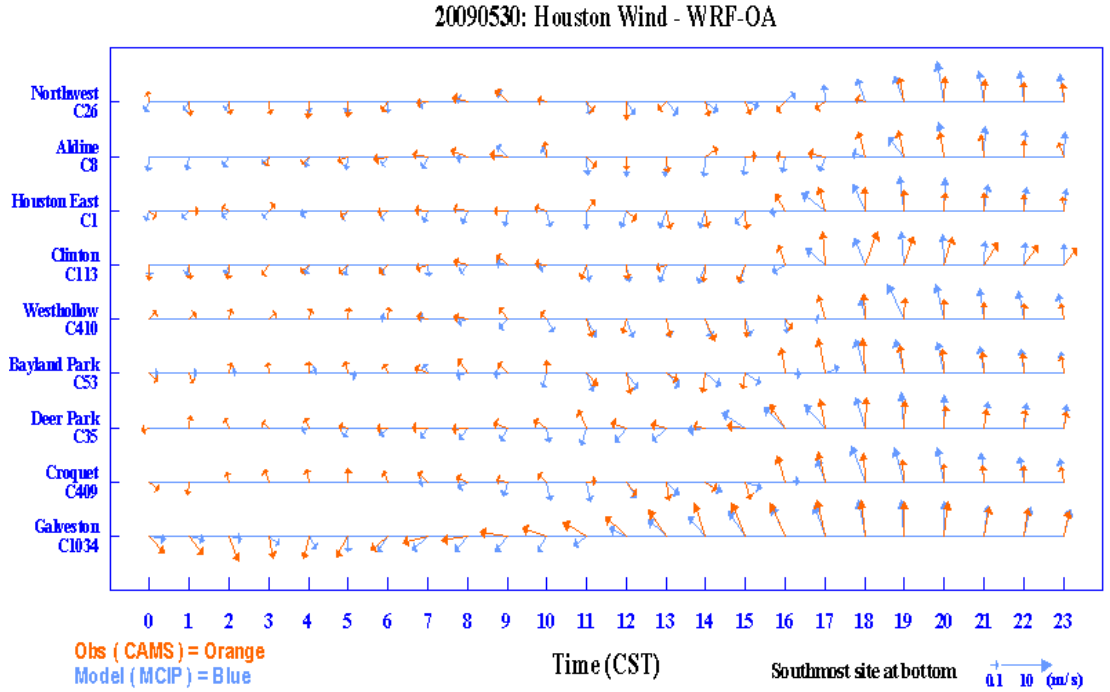
Observation nudging

- FDDA is one of the most important components in modern NWP models
- Model performance gain is substantial while cost is relatively low
- Nudging is a FDDA method to push (or nudge) model values toward observation.
  - Grid nudging uses analysis input ('met_em' files from WPS)
  - Obs-nudging uses observation data (OBS_DOMAIN files from WRF-OBSGRID)
- Obs-nudging is performed every 3 hours, just like the grid nudging



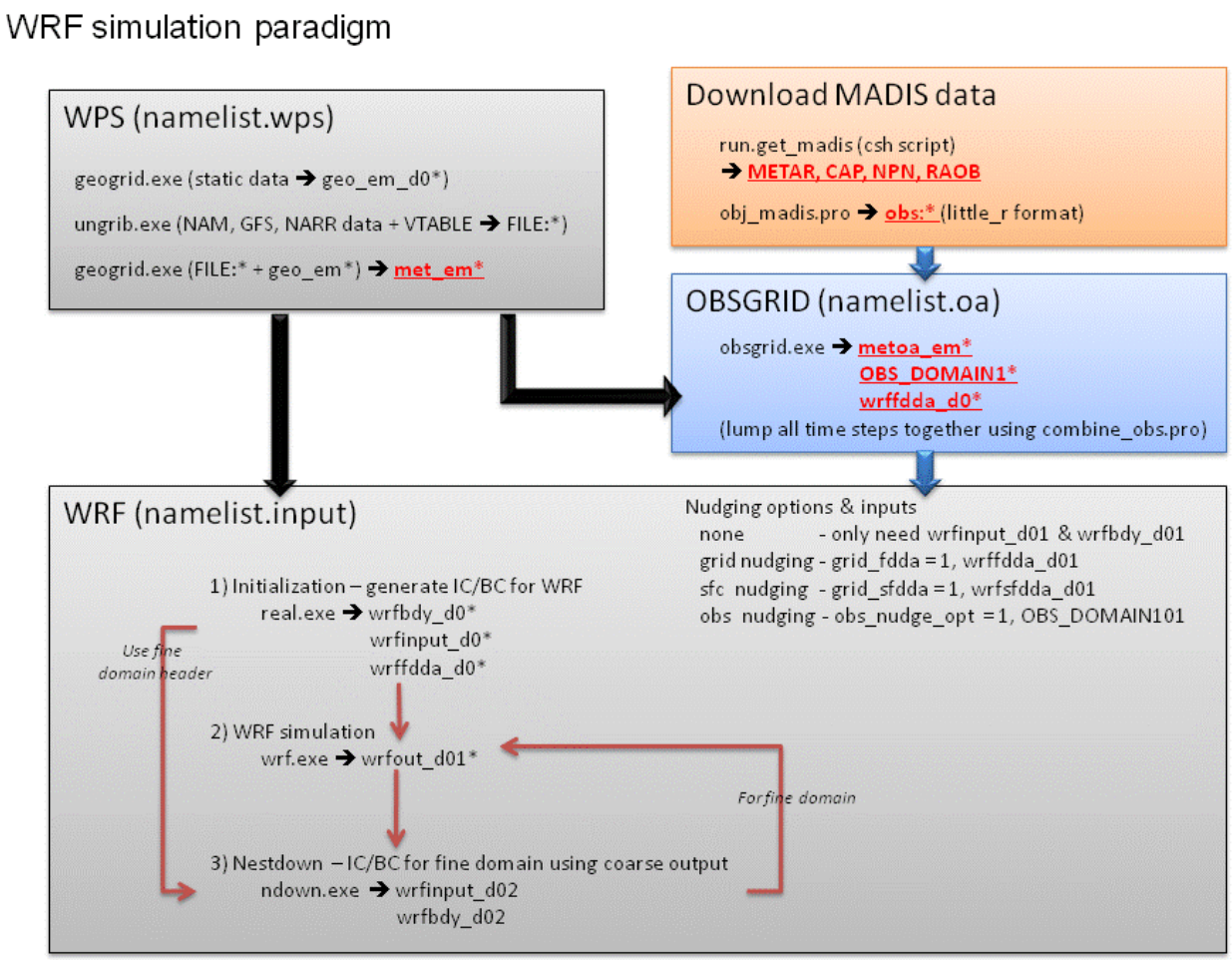
Improvement of IOA: Wind (U and V) 10-14%; Temperature 9%



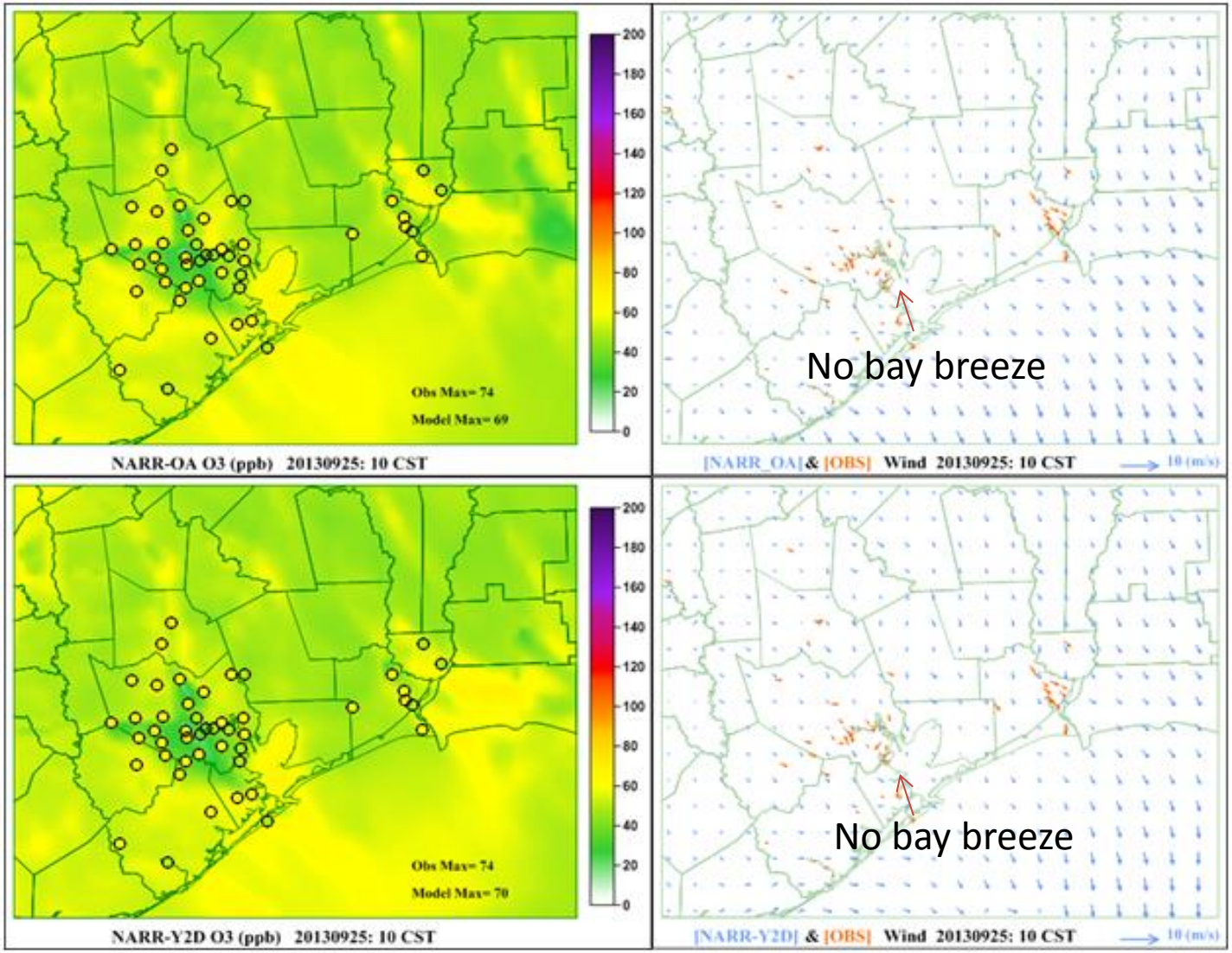


Improvement significant

WRF Obs nudging – op. flow chart



OA did not solve the problem for 09/25



Current work: Enhanced obs nudging

- In 09-25, last nudging is performed at 9 CST, yet baybreeze onset is at 10 CST
  - From 10 to 13 CST, there is only one nudging done at 12 CST -> Not enough push to 'bend' model!
- Possible solution
  - Increase the obs nudging frequency to hourly!
    - Data available, already preprocessed 
    - WRF does not support it 
  - Can we still do it?
    - Actively working on it!
      - First task (modify OBSGRID code) done! 
      - On 2nd task (modify WRF)